A new testing facility to characterize ESD hazards in industrial baghouse filters

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A NEW TESTING FACILITY TO CHARACTERIZE ESD HAZARDS IN INDUSTRIAL BAGHOUSE FILTERS

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ABSTRACT

Baghouse filters are common dust collection systems for pneumatic transport processes involving finely divided powder materials. However, safe use of these systems requires appropriate control of electrostatic charge and discharge phenomena. Numerous parameters may contribute to accidental inflammation due to uncontrolled ESDs. This is the reason why the experimental approach keeps the best way to investigate these complex hazards.

The facility has been instrumented to measure appropriate electrostatic fields, and charge patterns within the filter cabinet according to operating conditions and to the type of filtering bags mounted.

Preliminary results obtained in experiments illustrate how severe electrostatic charging and electrostatic accumulation can be in such a dynamic process involving finely divided powder material. It shows that worse electrostatic cases require high velocity and moderate powder concentration. Preliminary results also show that electrostatic potentials rise nearly instantaneously to their maximum and drop as soon as powder material runs out.

The on-going testing program as well as future research opportunities offered by the new facility will permit to test other powders and bags in order to build a safety electrostatic concept for baghouse filters.

1. CONTEXT & OBJECTIVES

Dynamic pneumatic transport and dust collection processes operating with powder materials are responsible for almost 20% of dust explosions [1][2]. This prevalence to explode can be explained, on the one hand, by the dispersion of finely divided combustible solids into the air and, on the other, by the electrostatic charge generation mechanisms inherent to material flows, likely to lead to incendiary electrostatic discharges. The more the powder materials in operation are resistive, the more the electrostatic manifestations are severe.

Baghouse systems are amongst the most commonly used of the industrial dust collecting techniques. The principle consists of placing fabric bags filtering solid particles in the dust-filled air flow. Their very function means that the bags can be the seat of a phenomenon due to electrostatic charge accumulation. The accumulation of said charges can go as far as generating incendiary electrostatic discharges in the event of accidental contact with an earthed extraneous conductive part.

Provisions as regards controlling ignition sources and, more especially, as regards preventing electrostatic discharges are governed by standardised reference manuals [5][6][7]. They classify electrostatic discharges by type according to the nature of the materials used and the electrification mechanisms. We have, therefore:

- spark discharges involving unearthed metal surfaces;
- brush discharges involving insulating surfaces;
- propagating brush discharges involving the association of an insulating cladding covering an earthed conductor in combination with a high charge generation mechanism.

The spark discharges as well as the propagating brush discharges are considered to be incendiary for all types of explosive atmospheres whilst the brush discharges are only incendiary for explosive atmospheres in which the minimum ignition energy is less than 3 mJ.

All these types of discharge can be expected in baghouse dust collection systems because of the different variations possible in installation and use configurations. Consequently, brush discharges can be expected in the event that the bags are insulating. Propagating brush discharges can also be expected if said insulating bags are supported by an earthed metal cabinet. And lastly, spark discharges can be expected if the bags are conductive and insulated against earthing.

Current methods used for assessing non-electrical equipment intended to be used in explosive atmosphere under European ATEX 94/9/EC directive [3] can not be applied to filtering bags because they are not "*apparatus capable of causing an explosion through its own potential sources of ignition*". However, explosion hazards should be under control with respect to the 1999/92/EC directive [4] on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres.

These technical and legal aspects prove the need to be able to conduct a specific electrostatic assessment for the filtering bags in their actual operating conditions in order to advise on safe conditions of use.

In this context, INERIS has launched the "BESP" (Baghouse ElectroStatic Phenomena facility) project with the aim of assessing the nature and intensity of electrostatic phenomena in dust collection systems according to installation and operating parameters as well as the incendiary potential of the expected electrostatic discharges.

This project is based on a "semi-industrial scale" test bench designed for this study.

2. TEST BENCH

The test bench aims to reproduce as realist an industrial baghouse dust collection system as possible. It has been specifically designed and instrumented to carry out the investigations required to assess the risks of electrostatic ignitions.

2.1 Operating principle

Air is sucked towards the dust collector via a pneumatic transport process, 100 mm in diameter and 4 meters long. The air flow rate is between 300 and 1,400 m^3/h. The powder material is stored in a hopper before being introduced into the pneumatic transport process via a distribution unit composed of a micro-metering device and a cellular air-lock. The material flow rate is between 25 and 75 kg/h.

The biphasic mixture then goes into the dust collector where it initially encounters an empty chamber. Here, the air is slowed down and directed towards the base of the filtering bags. The heaviest particles settle and are recovered in a tray at the bottom of the chamber. The finest and lightest particles, however, follow the air flow which rises and comes into contact with the filtering bags. The filter cake that forms on the bags in this way is regularly removed via jet pulses injected against the air flow through a set of two lines, situated on the clean air side. The dust-free air comes out via the upper casing of the dust collector and is then released outside. The filter comprises a total of 6 filtering bags. Each has a diameter of 160 mm and is 2,000 mm high.

General view of the test bench and a view of the inside of the filter

2.2 Controlling the test bench

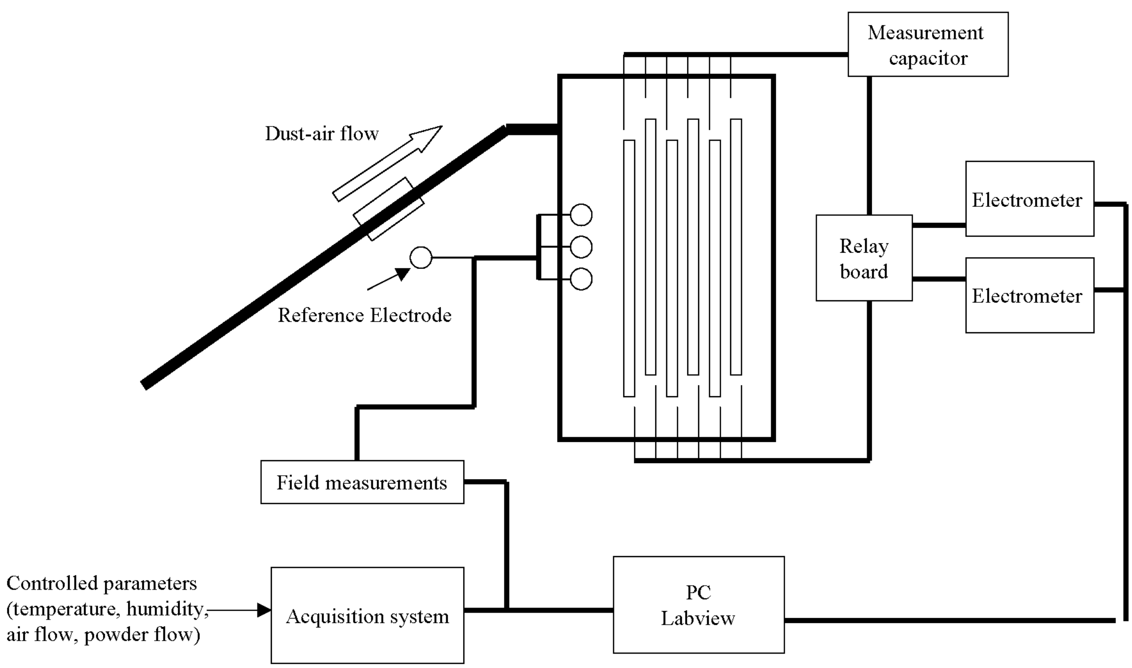
The air flow rate, therefore the speed of the flow, and the material flow rate, therefore the powder material dilution rate, are controlled by the researcher. The table below shows the operating range for the test bench. Temperature and humidity conditions are not checked; they are, however, systematically measured.

Air speed (m/s)	Minimum dilution rate (g/m3)	Maximum dilution rate (g/m3)
20	35	110
30	30	80
40	25	65

Test bench operating range

2.3 Instrumentation

The test bench has been instrumented in the aim of measuring the following electrostatic quantities:
- Measurement of the electric field radiated by the air line (reference electrode)
- Measurement of the electric fields radiated in the dust collector
- Measurement of the load currents specific to each bag
- Measurement of the leakage currents specific to each bag



Measurement synoptic

A relay board alternately polls the load current and the leakage current for each of the 6 bags automatically. The currents are measured by means of two electrometers; one electrometer measures the load current via capacitors and the other electrometer measures the leakage current via resistance. A program has been developed under Labview for data acquisition and processing.

The measurement principles were validated using a pilot test bench (cf. photograph below).

Pilot test bench for validating the measurement instruments

2.3 Test powder material

Talc was selected following a campaign measuring the characteristics of different powder materials likely to have an influence on electrostatic charges (resistivity, volume density, granulometry).

In addition to its incombustibility and its non-toxicity, talc has the advantage of highlighting the severest of electrostatic phenomena that it is possible to encounter in industry. This representativeness can be attributed to its low granulometry (median value < 50 µm) and its high resistivity (between 10^{10} and 10^{11} ohm.m). Talc is notably representative of the following powder materials: Maltodextrin, Whey, Corn Starch

3. PRELIMINARY RESULTS & DISCUSSIONS

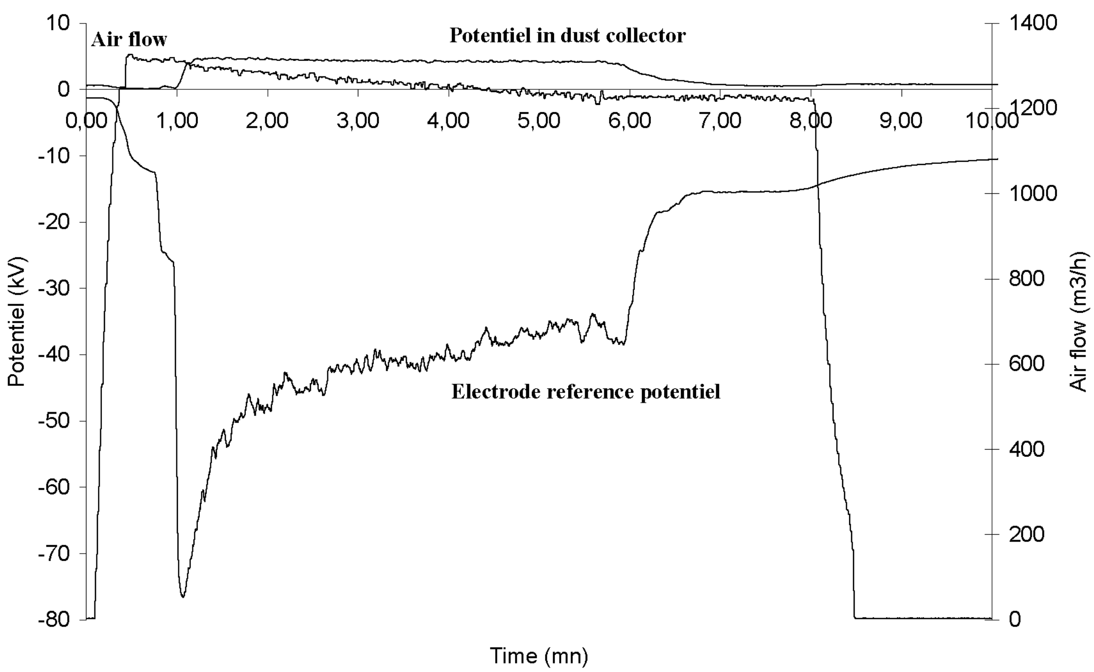
3.2 The strictest operating conditions

A series of preliminary tests was used to determine the conditions which enable maximum electrification of the powder material to be obtained. The results show that the electrostatic phenomena in the installation's operating range are severest when the air flow rate is set to its maximum (approx. 1,400 m^3/h) and the material flow rate to its minimum (approx. 25 kg/h). The electric potential measured using the reference electrode can thus reach 70 to 80 kV for air speeds of approx. 30 to 40 m/s in the air lines. They vary more widely between 10 and 80 kV throughout the operating range of the test bench.

3.4 Bag tests

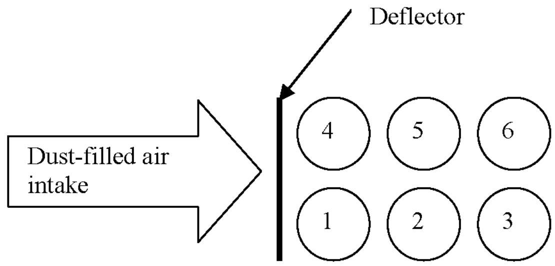
Initial tests were carried out using 6 bags with resistivity between 10^3 and 10^{11} ohm.m under the severest of previously defined operating conditions. The conductive bags were deliberately insulated against earthing to enable the charges to accumulate.

Measurements taken inside the filter show that the field rapidly reaches its maximum and remains stable throughout the testing until the talc runs out. The values recorded also show that the potentials are much lower than the reference electrode potential (cf. graph below). This drop in potential as well as the observed change in polarity can most probably be explained by the presence of the deflector at the entrance to the dust collector. It results in a significant dissipation to earth of the charge accumulated by the dust.

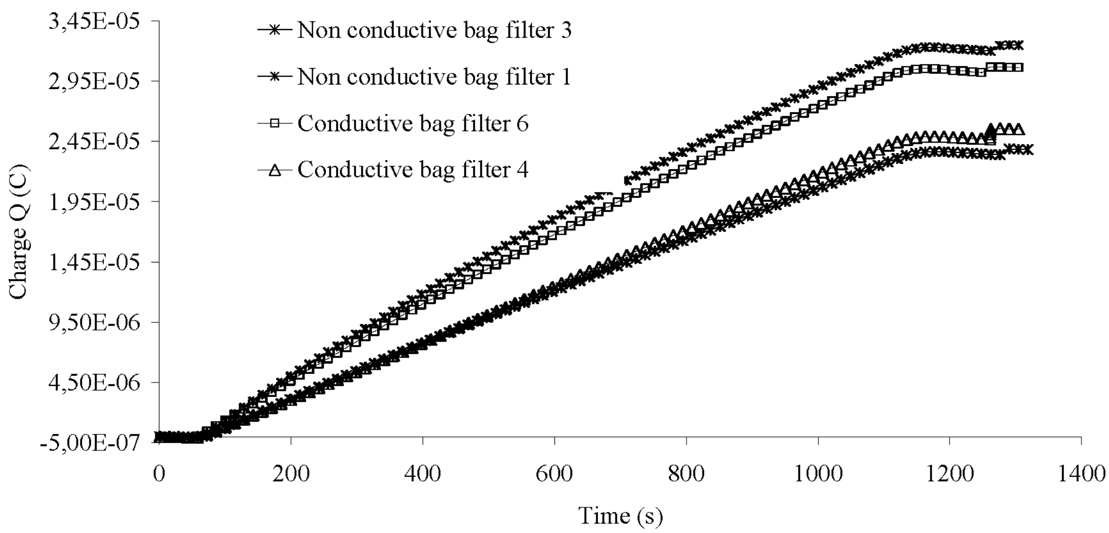


Potential measurement (40 m/s, 65 g/m^3)

The measurement results also show a variation in the charge build-up for the bags according to their position in the dust collector (cf. figure and graph below). Thus, the bags furthest from the air intake are those for which the load current is highest whilst those situated at the entrance, directly behind the deflector, are those for which the load current is lowest. These observations can probably be explained by the differences in the aeraulics encouraging the accumulation of dust on the bags to a greater or lesser extent according to their position.



Aerial view of the dust collector and position of the bags



Load current measurements (20 m/s; 50 g/m3)

These results also show that the effect of bag resistivity is not, in principle, significant. No interpretation is put forward at this stage of the project.

4- PRINCIPAL LESSONS AND PROSPECTS

The initial tests on conductive and insulating filtering bags have enabled the following principal lessons to be learned:

- the severest electrostatic phenomena are observed for maximum air speeds and for minimum dust concentrations in the test bench operating range;
- the electric fields measured are rapidly created once the installation starts-up and drop just as rapidly when the stock of talc runs out;
- the charge accumulated by the bags seems to depend more on their installation and operating conditions than on their electric properties;
- the further the bags are from the dust intake in the dust collector, the bigger the charge accumulated by the bags;
- the potential of the dust-covered bags is significantly lower than that recorded in the pneumatic transport line because of the presence of a deflector at the entrance to the dust collector. This, therefore, proves that physical and instrumental adaptations are essential for the next experiments in order to assess the power of the electrostatic discharges under the most unfavourable operating conditions;
- The load current measurements only make it possible to compare the bags with one another. This, therefore, proves that direct measurements of the potential of the bags are necessary in order to estimate by calculation the maximum power that an electrostatic discharge can dissipate for conductive bags insulated against earthing. A direct measurement of this power has to be envisaged when concerned with insulating bags.

As far as the study prospects prior to the formulation of pre-standardised recommendations are concerned, we plan to assess the influence of the nature of the powder materials (granulometry, nature) and the filtering bags (new or used) on the intensity of the electrostatic phenomena. We also have to be able, in principle, to estimate electrostatic phenomena intensity via computerised modelling.

5- THANKS

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